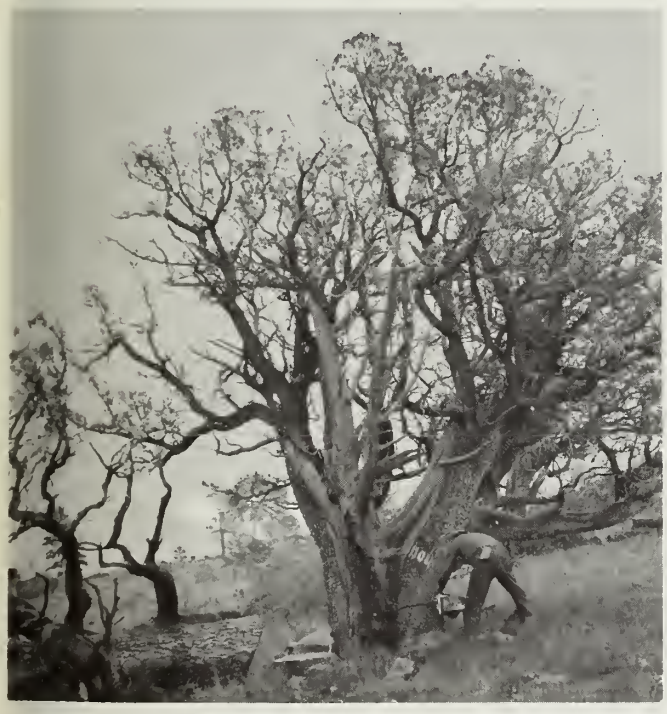
Effects of

TREE AND SAWYER FACTORS

on costs of

FELLING LARGE ALLIGATOR JUNIPERS



Robert L. Miller

Thomas N. Johnsen, Jr.

USDA Forest Service

Research Paper RM-56

July 1970

Rocky Mountain Forest and Range Experiment Station

Forest Service

U. S. Department of Agriculture

USDA Forest Service
Research Paper RM-56

1970

Effects of Tree and Sawyer Factors on Costs of Felling Large Alligator Junipers

by

Robert L. Miller, Associate Economist

Rocky Mountain Forest and Range Experiment Station[1]
U. S. Department of Agriculture, Forest Service

and

Thomas N. Johnsen, Jr., Research Agronomist

Crops Research Division, U. S. Department of Agriculture,
Agricultural Research Service[2]

[1]Central headquarters maintained at Fort Collins, in cooperation with Colorado State University; research reported here was conducted at Flagstaff, in cooperation with Northern Arizona University. Miller is now with the Department of Forestry, Oklahoma State University, Stillwater.

[2]Located at Flagstaff, Arizona.

Abstract

Costs of felling large alligator juniper trees are affected by tree conditions and stem diameter. Conditions that increased felling time were: (1) no appreciable lean or imbalance; (2) low-forked trees on which a second cut was necessary to reduce stump height to meet a treatment requirement; and (3) deteriorated and split stems which required vertical cuts to fell in more than one piece. Sawyer skill and safety were important factors in felling these trees. Possible alternative practices are suggested for trees with these conditions, and for very large trees.

Functions relating felling time and felling time per unit volume to stem diameter are provided. Results can be applied in treatment design and in estimating practice and harvesting costs.

Effects of Tree and Sawyer Factors on Costs of Felling Large Alligator Junipers

Robert L. Miller and Thomas N. Johnsen, Jr.

Alternative land-management programs involving substantial investments in removing alligator juniper (Juniperus deppeana Steud.) are underway in the Southwest. Large-scale clearing for forage improvement is currently practiced, and removal to increase water production is being studied. The potential exists for increased utilization of juniper in a variety of products.[3] Information is therefore needed on methods, costs, and means for reducing costs of felling junipers. This study reports the effects of tree characteristics, working conditions, and sawyer factors on felling time, and suggests alternatives that can be adopted to improve operational efficiency.

The data were taken during the treatment of a 100-acre experimental alligator juniper watershed within the Beaver Creek Pilot Watershed (Worley 1965) in central Arizona. The watershed was converted to herbaceous cover as part of a water-yield experiment.

Methods

The study was planned to obtain data on felling times and tree characteristics for as many large trees as possible. Many trees were studied because of the wide variations in several variables that appeared to affect felling time, and the apparent need to stratify these variables in the analysis. Tree size, growth habit, and other characteristics were recorded on 182 trees of 15 inches diameter at breast height (d.b.h.) or larger. Felling times were obtained on 133 of these trees. Time breakdowns of sawyer practices were also obtained as opportunities permitted.

[3] *Barger, Roland L., and Ffolliott, Peter F. The physical characteristics and utilization of major woodland tree species in the Southwest. 1970. (In preparation for publication, Rocky Mt. Forest and Range Exp. Sta., U.S. Dep. Agr., Forest Serv., Fort Collins, Colo.)*

Tree Characteristics

Data collected on tree characteristics included stem diameters at d.b.h. and at the cut, number of stems per plant, presence of dead material in stem and crown, crown diameter, tree height, and presence of lean or imbalance. Felling observations included number of undercuts made, vertical cuts to fell separate parts of a split stem, number and size of limbs cut prior to felling, and second cuts to reduce stump height.

Stem and crown conditions complicated measuring. Particular problems were the large variability in crown diameters and heights within stem diameter groups, and the frequency of multistemmed plants (fig. 1). These conditions would also limit photo interpretation. The 182 trees tallied grew as 159 plants, which also had an additional 16 stems less than 15 inches d.b.h. (stems of plants that forked below stump height were considered as individual trees). Crowns of these plants covered 5 percent of the total area.

Tree vigor, as evidenced by partly dead stems and crowns, varied widely. Compare the relatively vigorous crowns and sound stems (fig. 1) with partly dead trees (fig. 4). Vigor did not seem closely associated with size.

About 60 percent of the trees had partly dead crowns, and about the same proportion had dead material in the stem. Crowns classified as partly dead included one or more of these conditions: large dead limbs, many small dead limbs, or dead extremities in most limbs. Partly dead stems either had a "catface" or scar on the exterior of the stem, or more than a third of the cross section at the cut consisted of dry deadwood. Lightning or fire apparently caused most of the stem scars.

Deadwood in the stem is likely to increase felling time. No analysis was made to relate this condition to felling time, however, because of difficulty and doubtful accuracy of determining the amount of dead material in the cross section.

Tree and stand conditions are considered to be typical of many alligator juniper areas.

Figure 1.--Multi-stemmed and low-branching forms limit the use of d.b.h. as a measure of size.

Felling Time in Relation to Tree Characteristics

The need to examine factors that affect felling is pointed up by the extreme variations in felling time, and by the high costs experienced on many trees. Times varied from 1 minute to 2.25 hours per tree. The 133 trees studied required 30.1 man-hours to fell, exclusive of pre-limbing time (cutting limbs preparatory to felling) and time involved in moving between trees. Fifteen trees required 30 minutes or more each to fell.

Felling times or other costs of removal can be related to tree characteristics such as height or stem diameter.[4] Since diameter at the cut is more meaningful in sawing operations and is better than d.b.h. for measuring stem size of alligator juniper trees (fig. 1), it is used in this analysis.

A plot of felling times over diameter shows the relation of certain tree conditions to felling time (fig. 2). Tree conditions that increased felling time are: (1) no appreciable lean or imbalance (fig. 3); (2) low-forked trees on which a second cut was made to reduce a stump height to conform with the treatment requirement of low stumps; and (3) trees on which vertical sawing was required to separate and fell the tree in more than one stem portion (fig. 4).

Above 28 inches in diameter, these special felling problems caused much variability in felling times, and generally high cost. On the basis of these results, four out of five such trees will require from 10 to 45 minutes in felling time, with an average of 20 minutes or more. Problem trees above 28 inches in diameter may need to be considered as a separate group in management decisions.

[4] *The most suitable tree and cost variables will depend on the use of this relationship. For example, Cotner and Jameson (1959) related bulldozing and burning time to height of juniper trees, on the assumption that tree height is a good measure for the use of ranch operators. On the other hand, a relationship of felling time to stem diameter is preferable for use where inventory data on diameters are available, or where stem size is important, as in felling large trees with saws. If desired, d.b.h. (d) and diameter at the cut (D) can be interchanged by means of the following relationships computed from the data for trees 15 to 60 inches d.b.h.*

$$d = 1.15\ D - 3.56$$
$$D = 3.09 + 0.87\ d$$

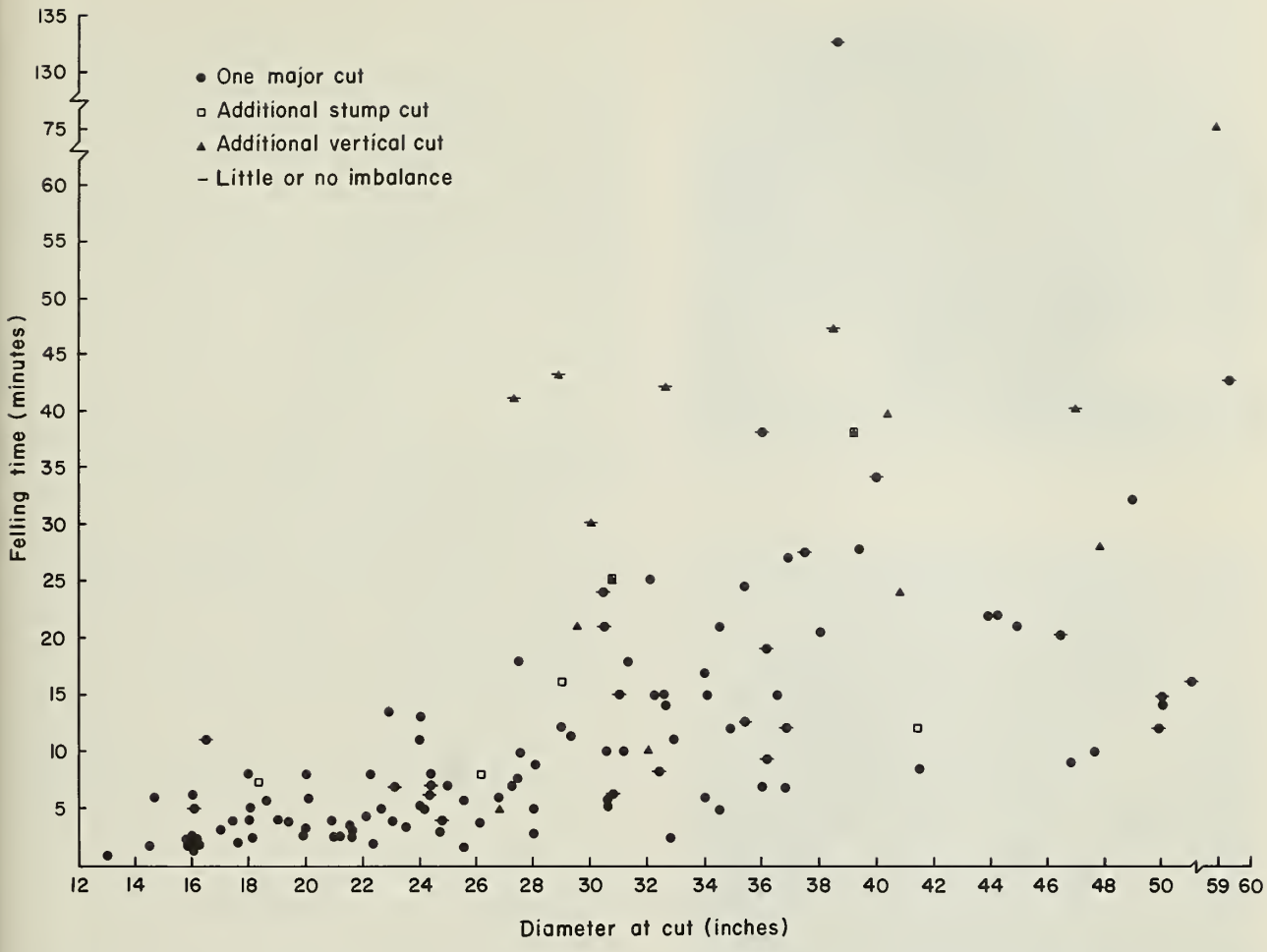


Figure 2.--Felling time of alligator juniper trees in relation to diameter at the cut.

Figure 3.--Trees with little or no imbalance tend to increase felling time. They make judgments on placing cuts and on time of fall difficult, and make felling hazardous. On this tree, an extreme case, the sawyer made five undercuts, cut off three limbs more than 12 inches in diameter to throw the tree off-balance, and used 2-1/4 hours to fell.

Figure 4.--Frequent partly dead and split stems adversely affect felling time and sawyer safety. They usually require felling in more than one piece with extra safety care, which involves additional undercuts and sometimes vertical cuts to separate pieces.

It should be noted that no trees below 27 inches in diameter had split stems that required felling in more than one piece.

Felling times for trees without special problems are plotted over diameter in figure 5. The regression provides a practical means for estimating felling costs per acre where information on number of trees by diameter class is available. For trees 15 inches in diameter, for example, an average felling time of about 2.5 minutes per tree can be expected. For each additional inch in diameter, felling time can be expected to increase from about 0.3 minute at 15 inches up to about 1 minute at 50 inches.

Sawyer Factors and Working Conditions

Working conditions and sawyer factors also need to be considered for ways to improve efficiency, and in extending results to other situations.

The full crew consisted of five sawyers and a foreman, using chain saws with 28-inch bars. Working conditions were good. No problems were presented by such factors as slope, rockiness, or associated vegetation. Trees tended to be distributed in groups, but spacing was such that safety of nearby workers ordinarily did not affect felling time.

Sawyer skill and experience were found to be especially important. Previous experience of the sawyers consisted mainly of thinning pine stands, where some work practices such as maintaining saw sharpness are likely not as important. Also, larger trees present felling problems that young pine stands do not. In felling the larger trees, especially under the conditions illustrated in figures 3, 4, and 6, sawyer skill must be proportionately much greater, and sawyer factors are more important than with smaller trees.

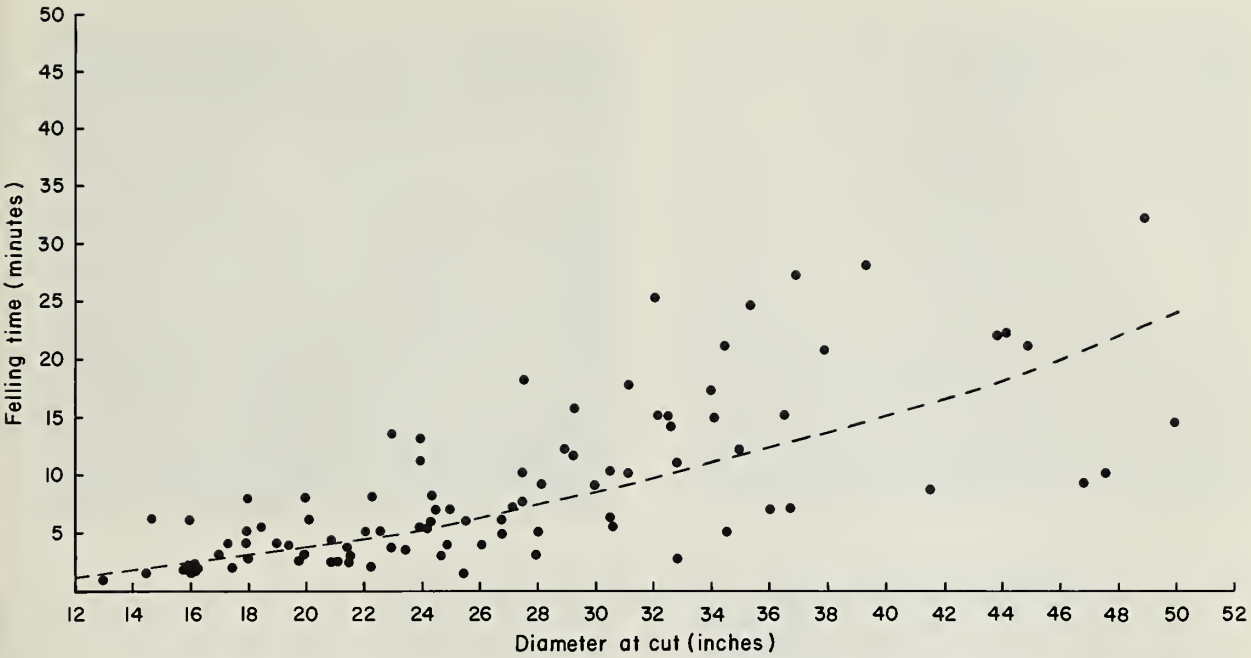


Figure 5.--Estimated regression of felling times of large alligator juniper trees on diameter at the cut.

The wide variations in tree conditions also require much judgment on how to fell, and when a tree is ready to fall. Safety measures tend to increase felling time, especially in the case of larger trees with little lean or imbalance (fig. 3), or split and partly dead stems that require felling in more than one piece (fig. 4). Frequent low-hanging limbs and large limbs on the ground are hazardous in that they obstruct movements (fig. 6). Sawyer safety should be carefully considered, therefore, in prescribing practices for felling large trees.

Times of various sawyer practices were separated for use in determining ways to improve felling efficiency. [5] Actual stem sawing time was recorded on 49 trees, along with notes on the use of time not applied in actual cutting. The proportion of felling time actually spent in cutting ranged from 15 to 100 percent, and averaged 69 percent. This proportion differed among sawyers.

Time not involved in actual cutting of stems was used in pre-limbing, servicing and adjusting saws, moving debris, and making judgments on how to fell. More than half of the trees required limbing; limbing time comprised 8 percent of total felling time for those trees.

Analysis of time breakdowns, and the felling problems discussed above, indicates the possibilities are good for reducing felling time substantially through improved felling methods adapted to the trees, changes in treatment prescription, and sawyer training.

Cost Implications of Some Alternative Practices

Felling costs can be reduced or avoided through alternative practices. For example, all trees with the felling difficulties noted above could be left uncut, or treated by an alternative method. It was previously reported that felling large trees (trees larger than about 9 inches stem diameter at the cut) required about 2.5 man-hours per acre, at a cost of $9.29 per acre. [6] On that basis, if trees

[5] *A more detailed analysis of sawyer practices is being published along with other data, in a separate report by the USDA Agricultural Research Service.*

[6] *Miller, Robert L. Clearing an alligator juniper watershed with saws and chemicals: a cost analysis. 1970. (In preparation for publication, Rocky Mt. Forest and Range Exp. Sta., U. S. Dep. Agr., Forest Serv., Fort Collins, Colo.)*

Figure 6.-- Low branches and severed limbs are hazardous, because they obstruct sawyer movement.

with the particular felling difficulties described were left uncut (less than one tree per acre), the job cost would have been reduced by about 0.47 man-hour per acre, a reduction of 19 percent, or $1.75 per acre.

As another example, 50 percent of the total felling time recorded was used in felling trees of 37.0 inches d.b.h. or larger (a total of 33 trees). Sawyers used 15.5 hours to limb and fell these trees. To leave uncut all trees larger than 37.0 inches would have reduced the total large-tree job cost by about 16 percent, or $1.51 per acre.

A particular treatment feature that increased costs was the requirement for a stump height of not more than 6 inches where practicable, primarily for esthetic reasons. However, practicable height usually turned out to be about 1 foot on the larger trees. In some cases, a second cut was made to reduce stump height. This requirement could easily be relaxed, especially in more remote areas.

Burning of some standing trees could reduce costs substantially. Some trees could be burned easily at little additional cost since some brush was piled, and piles could be placed around trees

to be burned. Although burning has been objected to on esthetic grounds, because of the dead trees left standing, it is possible that some partly dead and deteriorated trees could be almost completely burned.

A treatment could be designed to leave dead trees standing in areas not often observed by recreationists. If groups of live trees are left for esthetic, wildlife, and livestock shade benefits, other standing dead trees may be less conspicuous.

As a further consideration, individual old trees with sparse, partly dead crowns may not have an important effect on either water yields or on forage production, and easily could be left standing.

Some Applications to Juniper Harvesting

Large junipers are not marketable on the stump in any appreciable volume at present. Yet, commercial firewood operators removed all felled juniper stems of 6 inches or larger from the study area. This use of the felled trees indicates the importance of felling costs in restricting development of uses and markets for juniper.

In considering juniper harvesting operations, results from this study can be used in determining costs and in identifying trees that are too costly to fell and use. Many high-cost trees—those with partly dead and deteriorated stems and low forking—would not likely be usable for products other than firewood.

Where fiber volume is the main consideration, it is probable that trees with high felling costs can be eliminated from harvest without much sacrifice in total product volume per acre. For example, inventory estimates for alligator juniper on Beaver Creek indicate that trees larger than 37.0 inches d.b.h. make up only 11.3 cubic feet per acre, or 8 percent of the total volume.[7]

Available juniper volume tables can be used with the results of this study to estimate felling costs per unit volume for juniper trees of different diameters. Estimates for the Beaver Creek area, based on figure 5 and a local volume table,[7] are presented in figure 7. Felling cost per unit volume decreases at first, then increases as diameters become larger (fig. 7). Thus there may be two marginal stem sizes in a given operation. Marginal trees for given operations and markets can be identified by using these data along with information on pay rates, harvesting costs, and product values.

Summary and Conclusions

Costs, in terms of felling time, were affected by extreme variability in tree characteristics. Particular characteristics found to increase felling time were: (1) no appreciable lean or imbalance; (2) low-forked trees on which a second cut was made

[7] *See footnote 3, page 1.*

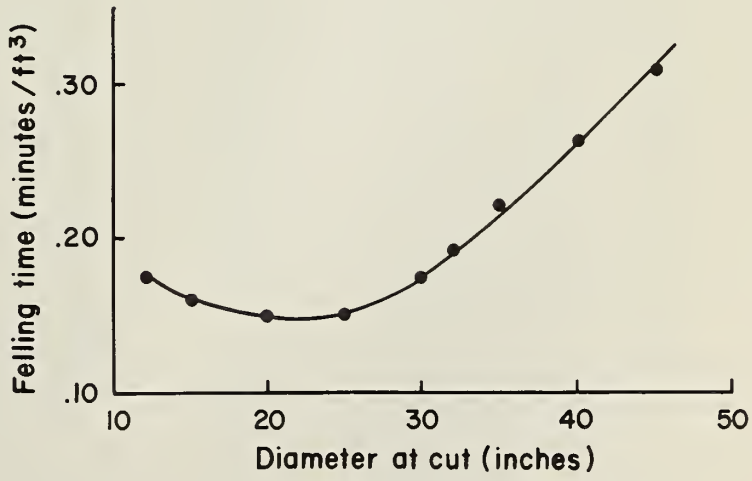


Figure 7.--Felling time per cubic foot as a function of stem diameter at cut (1-foot height).

to reduce stump height to meet a treatment requirement; and (3) deteriorated and split stems which required vertical cuts to fell in more than one piece.

A regression was developed that related felling time to stem diameter for trees without the above problem conditions. Times estimated by the regression range from about 2.5 minutes for trees 15 inches in diameter to 23 minutes at 50 inches.

Sawyer skill and safety are important in felling very large trees and trees with problem characteristics. No problems were experienced in other working and ground conditions. Overall treatment costs can be reduced without much adverse effect by burning, bulldozing, or leaving the high-cost trees untreated.

Results provide a basis for estimating juniper harvesting costs. A functional relationship between stem diameter and felling time per unit volume was established. With other available information, this relationship can be used to identify marginal trees for a given stand, and to estimate minimum market values needed for a profitable operation.

Literature Cited

Cotner, Melvin L., and Jameson, Donald A.
1959. Costs of juniper control: Bulldozing versus burning individual trees. U. S. Dep. Agr., Forest Serv., Rocky Mt. Forest and Range Exp. Sta., Sta. Pap. 43, 14 p., illus. Fort Collins, Colo.

Worley, David P.
1965. The Beaver Creek pilot watershed for evaluating multiple-use effects of watershed treatments. U. S. Forest Serv. Res. Pap. RM-13, 12 p., illus. Rocky Mt. Forest and Range Exp. Sta., Fort Collins, Colo.

Agriculture --- CSU, Ft. Collins

Miller, Robert L., and Johnsen, Thomas N., Jr.
1970. Effects of tree and sawyer factors on costs of felling large alligator junipers. USDA Forest Serv. Res. Pap. RM-56, 8 p., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado 80521.

Costs of felling large alligator juniper trees are affected by tree conditions and stem diameter. Conditions that increased felling time were: (1) no appreciable lean or imbalance; (2) low-forked trees on which a second cut was necessary to reduce stump height to meet a treatment requirement; and (3) deteriorated and split stems which required vertical cuts to fell in more than one piece. Sawyer skill and safety were important factors in felling these trees. Possible alternative practices are suggested for trees with these conditions, and for very large trees.

Functions relating felling time and felling time per unit volume to stem diameter are provided. Results can be applied in treatment design and in estimating practice and harvesting costs.

Key words: Alligator juniper, *Juniperus deppeana*, forestry business economics, tree felling costs.

Miller, Robert L., and Johnsen, Thomas N., Jr.
1970. Effects of tree and sawyer factors on costs of felling large alligator junipers. USDA Forest Serv. Res. Pap. RM-56, 8 p., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado 80521.

Costs of felling large alligator juniper trees are affected by tree conditions and stem diameter. Conditions that increased felling time were: (1) no appreciable lean or imbalance; (2) low-forked trees on which a second cut was necessary to reduce stump height to meet a treatment requirement; and (3) deteriorated and split stems which required vertical cuts to fell in more than one piece. Sawyer skill and safety were important factors in felling these trees. Possible alternative practices are suggested for trees with these conditions, and for very large trees.

Functions relating felling time and felling time per unit volume to stem diameter are provided. Results can be applied in treatment design and in estimating practice and harvesting costs.

Key words: Alligator juniper, *Juniperus deppeana*, forestry business economics, tree felling costs.

Miller, Robert L., and Johnsen, Thomas N., Jr.
1970. Effects of tree and sawyer factors on costs of felling large alligator junipers. USDA Forest Serv. Res. Pap. RM-56, 8 p., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado 80521.

Costs of felling large alligator juniper trees are affected by tree conditions and stem diameter. Conditions that increased felling time were: (1) no appreciable lean or imbalance; (2) low-forked trees on which a second cut was necessary to reduce stump height to meet a treatment requirement; and (3) deteriorated and split stems which required vertical cuts to fell in more than one piece. Sawyer skill and safety were important factors in felling these trees. Possible alternative practices are suggested for trees with these conditions, and for very large trees.

Functions relating felling time and felling time per unit volume to stem diameter are provided. Results can be applied in treatment design and in estimating practice and harvesting costs.

Key words: Alligator juniper, *Juniperus deppeana*, forestry business economics, tree felling costs.

Miller, Robert L., and Johnsen, Thomas N., Jr.
1970. Effects of tree and sawyer factors on costs of felling large alligator junipers. USDA Forest Serv. Res. Pap. RM-56, 8 p., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado 80521.

Costs of felling large alligator juniper trees are affected by tree conditions and stem diameter. Conditions that increased felling time were: (1) no appreciable lean or imbalance; (2) low-forked trees on which a second cut was necessary to reduce stump height to meet a treatment requirement; and (3) deteriorated and split stems which required vertical cuts to fell in more than one piece. Sawyer skill and safety were important factors in felling these trees. Possible alternative practices are suggested for trees with these conditions, and for very large trees.

Functions relating felling time and felling time per unit volume to stem diameter are provided. Results can be applied in treatment design and in estimating practice and harvesting costs.

Key words: Alligator juniper, *Juniperus deppeana*, forestry business economics, tree felling costs.

About The Forest Service. . . . .

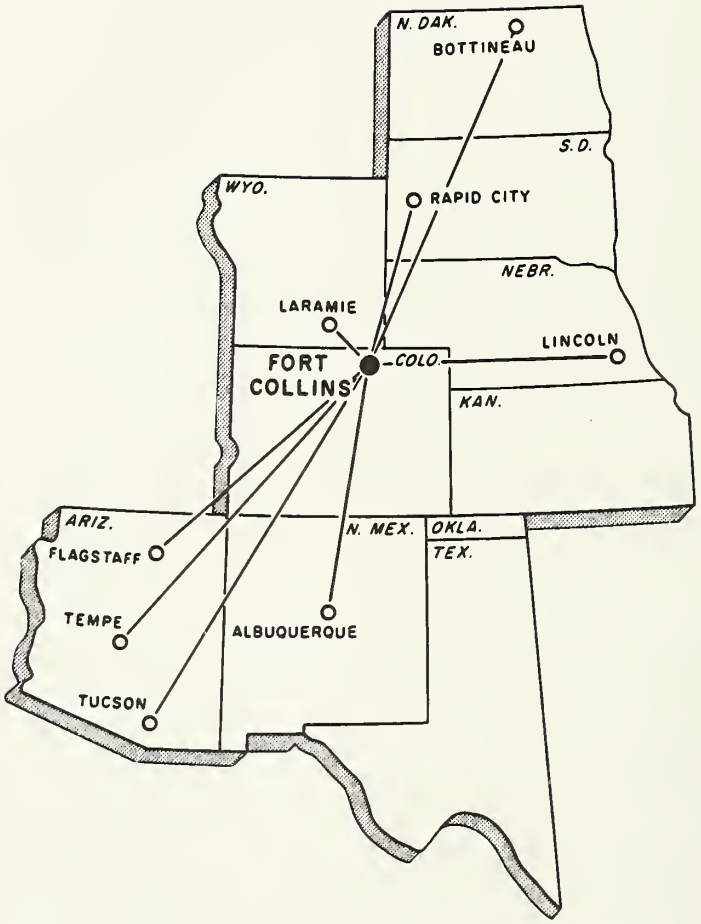
As our Nation grows, people expect and need more from their forests—more wood; more water, fish and wildlife; more recreation and natural beauty; more special forest products and forage. The Forest Service of the U. S. Department of Agriculture helps to fulfill these expectations and needs through three major activities:

- Conducting forest and range research at over 75 locations ranging from Puerto Rico to Alaska to Hawaii.
- Participating with all State forestry agencies in cooperative programs to protect, improve, and wisely use our Country's 395 million acres of State, local, and private forest lands.
- Managing and protecting the 187-million acre National Forest System.

The Forest Service does this by encouraging use of the new knowledge that research scientists develop; by setting an example in managing, under sustained yield, the National Forests and Grasslands for multiple use purposes; and by cooperating with all States and with private citizens in their efforts to achieve better management, protection, and use of forest resources.

Traditionally, Forest Service people have been active members of the communities and towns in which they live and work. They strive to secure for all, continuous benefits from the Country's forest resources.

For more than 60 years, the Forest Service has been serving the Nation as a leading natural resource conservation agency.


N. DAK.
BOTTINEAU
S. D.
WYO.
RAPID CITY
NEBR.
LARAMIE
LINCOLN
FORT COLLINS
COLO.
KAN.
ARIZ.
N. MEX.
OKLA.
TEX.
FLAGSTAFF
TEMPE
ALBUQUERQUE
TUCSON